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Cold Seal Adhesives
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Cold seal adhesives are used in packaging of confectionery and bakery goods, medical packaging, specialty papers (envelopes and labels), and some industrial applications. Cold seal adhesives will be defined, their chemistries explored, problems encountered with and trouble shooting discussed, and future applications of cold seal will be discussed.

Cold seal adhesives are adhesives which seal to themselves when pressure only is applied. This makes them a desirable adhesive for products that are heat sensitive such as confectionery products. There is no potential exposure of the product to heat that can cause damage to the product. Packaging line stoppages are not as damaging if they occur because of the lack of heat. Packaging line speeds are also increased using cold seal adhesives rather than heat sealable adhesives or films, because a cold seal adhesive will seal with 0.5 seconds of dwell time versus a typical heat seal dwell time of 1 or 2 seconds. The increased line speed can be seen from Chart 1. It is also of interest to note that if a line stoppage occurs with a heat seal coating, besides damage to product, film damage may occur – causing a waste of film. Line stoppages do not adversely impact cold seal films, meaning that a line stoppage will not cause waste of cold seal films.

Cold seals are usually formulated by combining an adhesive component with an elastomer which provides cohesion. Additives are included to aid in the machining and stability of the cold seal. Elastomers used are both natural rubber and synthetic elastomers. Vinyl acetate polymers and copolymers are widely used as the adhesive component of the cold seal, and acrylic polymers are also widely used as the adhesive component of the cold seal. The vinyl acetate polymers tend to have lower glass transition temperature than many of the acrylic polymers. The vinyl acetate based cold seals are therefore softer and tackier, but because of this they also have a greater tendency to cause blocking than the acrylic based cold seals. Blocking is defined as the resistance to unwind in a roll of converted material. When blocking is severe, the roll will not unwind without causing damage to the film; severe blocking can also cause jerking of the roll stock on unwind which can cause problems on packaging equipment. Converted rolls of cold seal containing material should unwind smoothly with no cold seal pick off. Due to the nature of vinyl acetate and its copolymers as well to its lower hydrolytic stability as compared to acrylic polymers, vinyl acetate based cold seals have a greater tendency (although still being low odor) to impart odor to package contents. Finally, the acrylic products typically form water clear films while the vinyl acetate based cold seals have a hazy appearance. This clarity is useful when a clear film is used in packaging. Both types of cold seals can be formulated to apply well with gravure cylinders.

Natural rubber (from natural rubber latex) is the most commonly used elastomer in cold seals. Natural rubber is 1,4 cis-polyisoprene. It has a number average molecular weight of 300,000 and a wide range of particle sizes.(1) This wide variation in particle size means that natural rubber latex is

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not extremely mechanically stable (balls and strings form easily from natural rubber latex when it is placed under shear). Products containing natural rubber latex must be carefully formulated for mechanical stability. Care must be taken when handling natural rubber latex and compounded materials containing it such as cold seal adhesives— low shear pumps and agitators must be used. Piping should be fairly large diameter (7.5 cm or more) to prevent shearing from occurring during transfer of latex. New developments in press technology are reducing the mechanical stress on the product and are beneficial to the cold seal converter. Besides 1, 4 cis-polyisoprene, there are some non-rubber components of natural rubber latex. These include ammonium salts, carbohydrates, and some trace inorganic salts (2). The composition of non rubber solids varies due to time of year of harvest, weather, soil and country of origin. When working with naturally occurring substances, one must be cognizant of these differences in the product and possible effects these differences can have on the product.

The source of natural rubber latex is the tree, *hevea brasiliensis*. All trees used in rubber production are clones of each other. A disease in South America virtually killed all the trees in the region. Fear of the transport of this blight to plantations in Southeast Asia and Africa are one reason to formulate a cold seal product with synthetic elastomers.(3) Another reason is the harvest of natural rubber; this is very labor intensive, sometimes dangerous work. As the nations where rubber is grown are becoming more industrialized, the labor pool of rubber harvesters is shrinking. Also, the global supply of natural rubber is having a hard time keeping up with demand. As petrochemicals have increased in price, natural rubber becomes more attractive for use in applications where either natural rubber or synthetic rubber could be used.(4) A third reason is that there is a protein in *hevea* latex which causes allergic reaction in some people. The concern about allergic reaction is causing some confectionery manufacturers to evaluate synthetic based cold seals.

Synthetic elastomers used include styrene butadiene rubber (SBR), polychloroprene and butyl rubber. Another chemistry that may be viable for synthetic cold seal would be a purely acrylic system. Each of these products has its strengths and weaknesses. The synthetic elastomers do not cold flow as well as the natural rubber latex, which allows for "caulking" or filling of the gaps in the seams of the package. They also have a different odor than the natural rubber which causes concerns in packaging line operators. The synthetic based cold seals have passed flavor and odor tests conducted by confectionery companies.

Finally, there may be a difference in the feel of the peel with the synthetic cold seals. The synthetics have a more zippery peel than the natural rubber based cold seals.

Cold seals for confectionery packaging are most often used on horizontal filling equipment. Due to the nature of the fill, extremely high green tack numbers for cold seal are not required. In practice, sealing conditions vary widely due to deficiencies in packaging equipment or maintenance. Adequate seals must be obtained when jaw pressures are as low as 40 psi. In addition to having adequate bonds, rolls of cold seal stock must unwind smoothly on the packaging equipment. The amount of cling of the cold seal surface to the release surface can be measured. A cling of less than 100 g/15 mm (0.8N/15 mm) is deemed acceptable for most cold seal applications in the US; cling values required for Europe are much lower. There must be no transfer of cold seal to the release surface under storage conditions. Products which are packed in cold seal packaging are moisture and oxygen sensitive. The manufacturers of these types of products make sure the cold seal adhesives

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provide the cohesion needed to protect the food. Some of this testing involves applying vacuum to the packages and measuring the point at which packages burst. For example, three cold seals were coated on a white OPP film at various coating weights. Packages were made, placed in a water vessel, and placed into a vacuum oven. The vacuum was gradually increased, and the point noted where the packages leaked was recorded. The results are summarized in the table below:

Cold seal	Coat weight	Mean in. Hg of failure	In. of Hg Failure range	Std. Deviation
Synthetic A	2.5 lb./ream 3.4 gsm	10.8	6 - 16	2.86
Synthetic A	3.2 lb./ream 4.3 gsm	12.3	8 - 15	2.45
Synthetic B	2.5 lb./ream 3.4 gsm	13.3	12 - 16	1.35
Natural Rubber C	2.9 lb./ream 3.9 gsm	13.9	10 - 16	1.97

1 in. Hg = 254 mm Hg

The cold seal must pass odor and flavor requirements as specified by the various end users. Typically, this involves storing coated stock in closed containers and noting off odors after a period of storage for odor testing. Flavor testing usually involves tasting product exposed to cold seal for off notes as compared to product exposed to a blank. The range of products packed in cold seal packaging goes from cookies and candies to ice cream bars and other frozen novelties. The cold seal must be able to seal at the low temperatures required for packaging these items as well as remain sealed under the storage conditions required.

In order to assure the cold seal will perform in the market, a variety of testing is performed in the lab. First, seal strengths on a wide variety of substrates are measured. Seal strength is coat weight, film, (see Chart 2), time after sealing (see Chart 3) and cold seal dependent (see Chart 4). A robust cold seal will give 400 pli bonds on a wide variety of substrates. The substrates used are changing frequently, so the cold seal supplier is constantly evaluating new films for cold seal performance. The cold seal bond strength depends on the dwell time between sealing and measuring the bond strength. A unique piece of equipment was developed for measuring peel value immediately upon sealing. This gives a measurement of the green tack of the cold seal, which can be important in cold seal performance on some packaging lines. One can also use this equipment to measure evolution of bond seal strength in a short period of time (7 seconds). This is useful for evaluating packaging behavior on a bar wrapping machine, and these characteristics are important to measure in order to help predict performance. Clings of the cold seal to the release surface must be measured. It must also be verified that the release surface does not contaminate the cold seal. What is done is usually to block cold seal surfaces to release surfaces at 100 psi. Clings and bonds in the blocked area are measured. Cling tests are performed at three conditions: ambient, 120°F (49 °C), and 100°F (38°C)

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90% relative humidity. These conditions simulate warehousing and trucking conditions converted stock may be exposed to. One must ensure that cold seal performance will not degrade due to warehousing or transportation of converted stock.

The handling and storage of both wet cold seals and converted stock is crucial in cold seal performance. Cold seals are perishable and should be used within the specified shelf life. They need to be protected from freezing. Cold seal needs to be well mixed before using. High shear mixing and pumps are to be avoided due to mechanical stability issues with natural rubber latex. Handling and mixing equipment should be stainless steel, and contact with copper should always be avoided. Rewind tension should be controlled; too tight a wrap may cause blocking. Chill rolls must be set at temperatures above the dew point to prevent condensation on the wrap giving blocking and in some cases lower seal strengths. Coated rolls should be wrapped for best results. Long periods of storage at high heat and or humidity should be avoided to prevent blocking.

Future opportunities for cold seals are varied. Improved performing synthetic cold seals (better caulking, improved green tack, and lower pressure sensitivity) for the confectionery market are of interest. Synthetic cold seals for the medical packaging market are needed. A niche area for cold seal packaging would be to have a cold seal that peels open and can be resealed. The application would be for a multiple use product (e.g. cookies, snacks or larger serving size bags of candy) so that the package can be reclosed via cold seal. This would be a significant cost savings over present uses of zipper type closures. Developments are occurring in this area.

Maximum packaging speeds

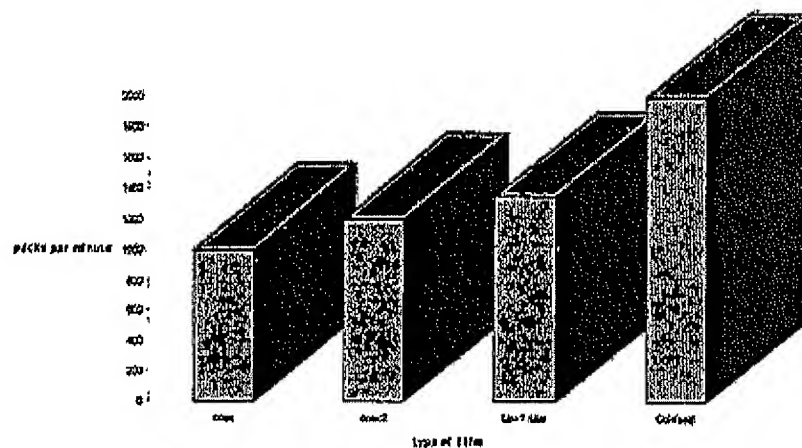


Chart 1 Packaging line speeds vs. type of film.

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Bond strength as a function of coat weight

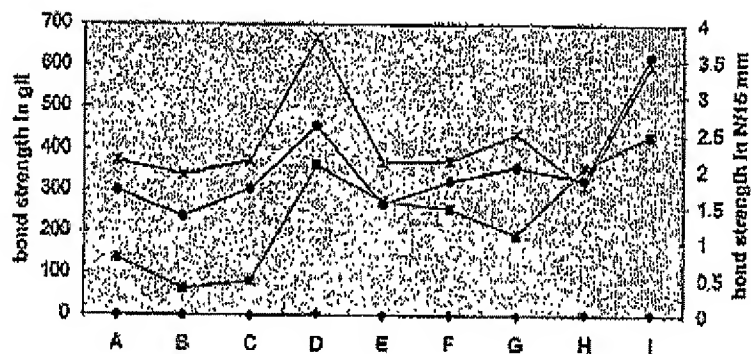


Chart 2: Bond strength of a cold seal on 7 different substrates at 3 coating weights. The trend is for bond strength to increase with coat weight -- the top line represents 3 lb./ream (4.8 gsm), the middle line 2 lb./ream (3.2 gsm), and the bottom line 2 lb./ream (3.2 gsm). Bond strength depends on film

Bond strength as a function of time

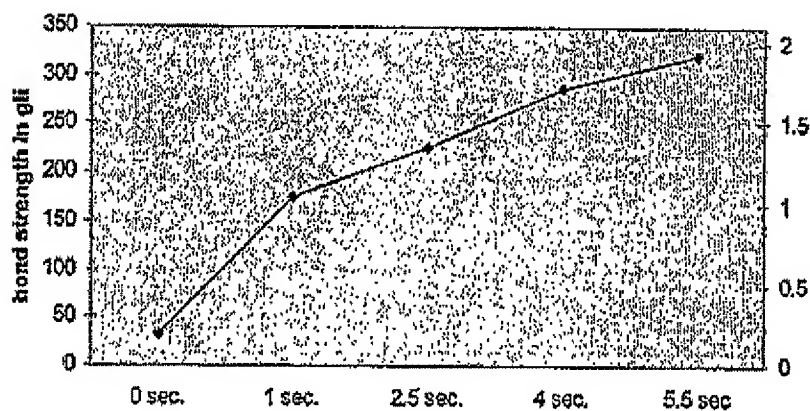


Chart 3. Bonds increase as time after sealing increases.

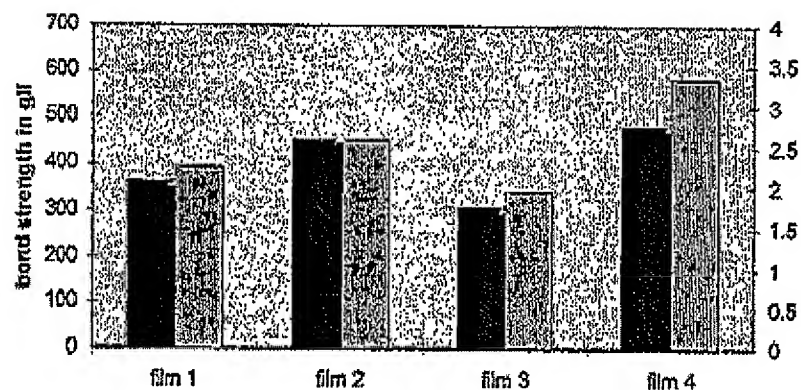
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Chart 4. Bond strengths for two different cold seals on 4 different films. Cold seal coating weights are 3 pounds per ream (4.8 gsm).

References

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